



METHODS AND EQUIPMENT FOR THE MEASUREMENT OF
THE THREE-DIMENSIONAL DISTRIBUTION OF THE TEMPERATURES
WITHIN DIELECTRIC MEANS OBJECTS

Field of the Invention

A new type of tomograph has been invented that is able to ~~rebuild~~ map the three-dimensional distribution of ~~the~~ temperatures present within ~~the~~ dielectric objects, including biological objects. Although the instruments may be used in all fields, one of its most important uses is ~~that which~~ in the medical diagnostic field, considering that it may allow ~~the definition of the a~~ three-dimensional thermal map of human internal organs to be defined.

The instrument is made up of:

1. ~~Electromagnetic wave emission sensors that are able to detect radiation with wave lengths that go from the millimetre, centimetre, and metre waves to those of the infrared radiation.~~

2. ~~All structural elements and the mechanical and electronic accessories necessary to assemble and move the aforesaid sensors, so as that the sensors themselves can detect most suitably the heat emissions of the dielectric objects, according to the given directions and distances.~~

3. ~~An electronic co-ordinator for the automatic management of the instruments.~~

4. ~~Software for machine management and for the elaboration of the three-dimensional distributions of the temperatures in the dielectric objects.~~

~~DESCRIPTION OF THE PREVIOUS STATE OF THE ART~~

Background of the Invention

The present invention concerns an instrument and a methodology for the determination of ~~the~~ a three dimensional distribution of the temperatures of ~~the~~ dielectric objects, non- invasively. It is based on the possibility of measuring, with extreme precision, the electromagnetic heat emission that results from within the internal presence of objects with temperatures superior to above absolute zero. All bodies that ~~are furnished with~~ have such temperature distributions ~~irradiate~~ radiate electromagnetic radiation in accordance with the law of ~~Plank~~ Planck: from a physical point of view there is thus a certain quantity of internal heat that is ~~irradiated~~ radiated externally as electromagnetic radiation. The power emitted depends principally on the temperature of the body and on ~~the~~ its emission properties ~~of the same body~~. The electromagnetic wave emission power of the objects can be described as not very elevated frequencies (until the infrared zone) through ~~Raley~~ Rayleigh-Jeans type equations and it proves ~~hence~~ to be directly proportional to:

- the square of the frequency;
- the emission coefficient, between zero and one, that in turn depends on the frequency;
- the body temperature; and
- the Boltzman constant.

The emission power however, at room temperature, reaches ~~the~~ a maximum in the infrared zone, but decreases, exactly ~~squarely as compared to~~ as the square of the frequency, for lower frequencies;. Because of this, the detection of the power irradiated by the object in ~~millimetre, centimetre and metre waves~~ the millimeter, centimeter and meter wavelengths, becomes a much more critical problem and requires extremely ~~sensible~~ sensitive sensors. Surveys that are able to precisely measure the objects' emission power, in this frequency range, have become accessible in the last years. The first surveys; in this frequency field were the Dicke radiometers ~~radiometres~~ (1; 2). However even these sensors have not been greatly used because of the measurement errors introduced principally by the reflection of the ~~irradiating~~ radiating power emitted by the objects on the level of the interface between the ~~same~~ objects and the ~~surveyor's~~ sensor's antenna. There have been various attempts to correct this undesired effect. An initial solution to the problem was presented by Ludeke et al in 1978 ~~Ludeke et. Al. In 1978 (3). While more~~ More recently, more effective solutions were presented by Troitskii and Raklin (4), and Holodilov and Ulianichev (5). The latest generation

of sensors, commonly defined as radiothermometers now allows one to measure, with extreme precision, the physical temperature of ~~the~~ dielectric objects without errors caused by the reflection of the power that ~~irradiates~~ radiates towards the interface between the object and the sensor antenna. In the radiothermometer proposed by the inventors ~~these authors~~, the antenna is connected through a modulator of the first arm of a circulator. The second arm of this circulator is connected to the input of the radiometer. The radiometer has within itself a reference high tension generator that feeds the modulator. In this case, a resistance, in thermal contact with the temperature transducer, is ~~the~~ a noise generator. The output of the resistance is connected both to the output of the radiometer, through a high frequency de-coupling element (~~inducer~~ inductor), and to the third arm of the circulator through a fitting capacitor ~~condenser~~. The radiometer stops feeding the resistance when its temperature is identical to the object's temperature.

Ultimately, the problem of detecting electromagnetic emission in the wave length field that goes from ~~millimetres~~ millimeters to meters can be considered solved, and the present invention, that will use as electromagnetic radiation sensors the aforementioned radiometers, benefits from this.

The instrument ~~object~~ of the present invention requires the extension of the frequencies detectable until the infrared zone. This proves comprehensible if one considers that the penetration power of the electromagnetic waves in the dielectric objects is directly proportional to the wavelengths of the radiation, which in turn inversely depends on the square root of the dielectric constant of the intersected object. When it is ~~required-rebuild~~ desired to map the internal temperature distribution of a determinate object, it is therefore necessary to have at one's disposal detectors that are ~~sensible~~ sensitive to an ample range of frequencies so ~~as~~ that measuring the power irradiated in ~~growing~~ increasing wavelengths, starting from the infrared, deeper and deeper layers of the investigated object are gradually characterized ~~characterised~~. The necessity of extending the frequency field to the infrared is not a problem because the availability of the infrared sensors is much broader (6). Even if the instrument, ~~object~~ of the present invention, is useable in all fields in which one wishes to determine the three-dimensional distribution of the temperatures within any dielectric object,

a particularly important application ~~regards the building~~ is the generation of three-dimensional thermal maps in human internal organs, and from this point of view, the instrument is of great interest for medical diagnostics.

In order to illustrate the effect of the invention on the medical diagnostic sphere, and the considerable innovation level, its use will be referred to as Radiomammography, and the instrument will be referred to as a Radiomamograph, that is, ~~as~~ an apparatus that is able to produce three dimensional thermal maps of internal sections of the breast. This internal organ is particularly exposed to ~~tumour~~ tumor pathology attacks. Breast cancer is one of the main problems of modern oncology. At the moment, the most used diagnostic method for detection of a breast tumour tumor is the X-ray mammography, ~~of which have~~ has been seriously ~~analysed~~ analyzed, both in its ~~the~~ use limitations and ~~the~~ its diagnostic criteria. It is a universally ~~recognised~~ recognized fact by this time that x-ray application in mammography ~~mammographs~~ currently in use represents an important factor of ~~tumour~~ tumor pathology induction. In 1997, the World Health ~~Organisation~~ Organization ~~has~~ identified ~~the~~ Mammography as the third risk factor for breast cancer. Hence, many important world health ~~organisations~~ organizations, such as the Department of Health and Human Services (USA) and the National Cancer Institute (USA) urge the scientific world to develop new methods for the early ~~precocious~~ diagnosis of breast cancer.

For some years now, the possibility of applying, to the ~~diagnosis~~ detection of breast ~~tumour~~ tumors, techniques such as MRI (Magnetic Resonance Imaging) and PET (Positron Emission Tomography) has been investigated ~~experimented~~, that These techniques, however, subject the ~~analysed~~ analyzed organs to strong electromagnetic fields whose effects on the cells are not completely known. Besides, these methodologies, because of their expensiveness and the various limitations that they encounter, cannot be used for population prevention screening.

The mammography technique, in addition to the inconvenience represented by its intrinsic invasiveness and riskiness, presents still another important limiting factor: its low spatial resolution on soft tissues. In the case of breast cancer, it is very difficult to ~~diagnose~~ detect ~~tumours~~ tumors whose size ~~is~~ are inferior to smaller than two centimeters ~~centimetres~~. that

generally have behind them already ~~have~~ a long incubation period.

The present invention ~~proposes, repropose~~ amongst other things, the solution of the problem of ~~precocious~~ early detection of breast cancer through the application of an investigation method that is able to discover the presence of a ~~tumour~~ tumor in its initial development phase. In particular, the present invention ~~regards~~ concerns a method and its ~~relative~~ related instruments for the ~~building~~ generation of three-dimensional thermal maps that allow the identification of inflammation ~~centres o tumour~~ centers of tumor masses ~~or whatever else~~ with its presence within tissues ~~is able to modify it~~ even weakly radiating (tenth of degrees). Explicitly referring to the identification of ~~tumour~~ tumor pathologies, it is ~~detected~~ known that the ~~tumour~~ tumor tissue differs from the healthy ~~one~~ tissue for a series of biochemical parameters. The ~~tumour~~ tumor cells present a low accumulation efficiency of the metabolic energy that is dispersed thermally, giving rise to a temperature increase of the ~~tumour~~ tumor mass as compared with that of the healthy tissues. It is furthermore acknowledged that any local inflammation ~~cause~~ is ~~however~~ linked to more or less ~~localised~~ localized temperature increases.

Summary of the Invention

The instrument is made up of:

1. Electromagnetic wave emission sensors that are able to detect radiation with wavelengths that go from the millimeter, centimeter, and meter wavelengths to those of the infrared.

2. All structural elements and the mechanical and electronic accessories necessary to assemble and move the aforesaid sensors, so as that the sensors themselves can detect most suitably the heat emissions of the dielectric objects, according to given directions and distances.

3. An electronic co-ordinator for the automatic management of the instruments.

4. Software for machine management and for the mapping of the three-dimensional distributions of the temperatures in the dielectric objects.

Brief Description of the Drawings

Figure 1 is a schematic diagram depicting the apparatus according to the invention;
and

Figure 2 is a map of a three dimensional temperature distribution within a dielectric
object as generated by the apparatus and method according to the invention.

INVENTION PRESENTATION

Detailed Description of Preferred Embodiments

The methodology that is proposed concerns the non invasive ~~definition~~ determination of the three-dimensional distribution of ~~the~~ temperatures within ~~the~~ dielectric objects, ~~with the inclusion of~~ including biological tissues and organs. This methodology ~~will use~~ uses sensors that are able to measure the heat radiating power emitted by the objects at different frequencies, within ~~the~~ a range that goes from ~~the~~ radio waves (wavelength one ~~metre~~ meter) to infrared waves (wave length one micron). The reception apparatus of such sensors ~~will be~~ is directed in space according to ~~fitting directions~~ appropriate specifications that will depend on the geometry and dielectric characteristics of the ~~analysed~~ analyzed object. Given that the effective layer thickness that contributes to ~~radioactive~~ electromagnetic emission depends on the wavelength of the monitored radiation, it will be possible to ~~rebuild~~ generate the three-dimensional distribution of the temperatures; within the ~~analysed~~ analyzed volume, that is, the value of the corresponding temperatures at small values (pixels) within the total ~~analysed~~ analyzed volume, measuring the power ~~irradiated~~ radiated at different frequencies ~~and by~~ placing the sensor antenna in correspondence with ~~of~~ a chosen set of points on the surface of the object that circumscribes the investigated volume.

Beginning from the thermal data measured at various frequencies and from various surface points, the ~~rebuilding~~ generation of the three-dimensional thermal maps of the investigated objects will be obtained through the application of ~~opportune~~ appropriate algorithms that will naturally take into consideration the topological data of the problem. The best approach for the solution of the problem of the ~~rebuilding~~ generation of the thermal field according to point values, initiating from integral data of the ~~irradiated~~ radiated power, is based on the use of the ~~Raley~~ Rayleigh-Jeans equation, that describes the connection between the emission

spectral density and the kinetic temperature of the elements of the object. On the other hand, the reconstruction generation algorithms of the three-dimensional thermal distribution may be based on models in which the link between the emission intensities and the temperature profiles are expressed through first order Fridgalm integrals (7,8).

- 5 The instruments, proposed in the present invention, will allow the measurement of the total emissions of electromagnetic ~~field~~ waves at various wavelengths, in the range between infrared and radio waves, and through various observation directions.

10 It will therefore contain a series of sensors that are able to measure ~~the~~ electromagnetic ~~field~~ waves in specific spectral bands. Such sensors are mounted on supports that are adjustable and removable in space: so as that, ~~remaining fixed the object of which one wants which to determine the three-dimensional distribution of the temperature,~~ the various sensors can be positioned in such away as to measure the emissions along directions that have been pre-established by the observer, with the object for which the three dimensional temperature distribution is to be determined remaining fixed. The movement of the sensors may occur
15 both automatically and manually.

The data measured by the sensors are sent through ~~opportune~~ appropriate interfaces to ~~the a~~ data ~~memorisation~~ recording system that ~~are~~ is able to re-elaborate the experimental information (total emission of electromagnetic waves of the object at various wavelengths and through various directions and/or distances), resolving integral equations with Fridgalm type methods, setting as output, the three-dimensional map of the temperatures of the object,
20 as shown in Figure 2. Such a map, in addition to being supplied as a table, can be presented on a screen or also printed as a thermal image.

~~An incomplete structural outline~~ A schematic diagram of the proposed instrument is ~~reported~~ shown in figure 1. The sensor battery (1) may be oriented on the basis of a program that the operator can ~~elaborate~~ control during the analysis. For example, the operator, on the basis of the observations, at certain wavelengths representative of the surface thermal distribution, can determine topological parameters for the sensor movement, operating at gradually growing
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increasing wavelengths, to better define the heat determinations of the deeper layers of the object. The output of the different frequency channels 2.1..... 2.n will be charged in command centre 3, that contains, in its interior, the elaboration unit 4 and co-ordination unit (5) of the entire instrument.

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